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Experiments in Rearing Calves Without Whole Milk and With Limited Amounts of Skim Milk

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INTRODUCTION

Rearing the 5 million or more dairy heifer calves that are saved for herd replacements each year in the United States takes enormous amounts of whole milk and skim milk. At the rates usually recommended the average for each calf would be about 550 pounds of whole milk and 2,900 pounds of skim milk, and 5 million calves would consume 95 million pounds of butterfat from the whole milk and 17 billion pounds of skim milk.

Recognizing the fact that calves are often fed more milk than they actually need for satisfactory growth and development, and that the excess milk might more profitably be diverted to human use, various investigators have from time to time undertaken to raise calves with smaller amounts of milk than are generally recommended. The purpose of this publication is to report the results of experiments by the Bureau of Dairy Industry, in which calves have been reared satisfactorily without whole milk and with limited amounts of skim milk.

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[1] The author acknowledges the helpful assistance of Elmer Cook, agricultural aid, who was in charge of feeding and caring for the experimental calves.

REVIEW OF LITERATURE

Many references in the literature could be cited to show that in general the milk-feeding recommendations for rearing dairy calves have remained practically unchanged for more than 75 years, especially for those areas where skim milk is available on the farm. The generally accepted schedule is—and has been for a long time—to feed the new-born calf colostrum milk for 2 or 3 days, follow with whole milk for 2 to 4 weeks, gradually substitute skim milk for the whole milk at the rate of 1 pound daily over a period of a week or 10 days, and then continue feeding skim milk to 6 to 8 months of age.

The amounts of whole milk and skim milk suggested by various authorities for this general feeding schedule are usually approximately the same. Those suggested by Shepherd and Miller (*25*)[2] in 1940 are about the average, and may be expressed by the following quotation:

> Never feed the strong vigorous calf more than 1 pound of (whole) milk per day for each 10 pounds of live weight, during the first 7 days. . . . After the change from whole to skim milk has been made, the quantity of skim milk fed can be increased by 1 pound daily every week or by 2 pounds daily every 2 weeks until the calf is getting the maximum quantity it is to be fed. If skim milk is plentiful, Jersey, Guernsey, and Ayrshire calves should be fed from 12 to 14 pounds and Holstein and Brown Swiss calves from 14 to 16 pounds daily.

Even larger amounts of whole milk and particularly of skim milk have been suggested, however. Henry (*13*) in 1898 stated: "The supply of full milk for the calf should not be over 10 pounds at first, and end with 15 pounds daily. The skim milk should not exceed 18 pounds until the calf is 5 weeks old, and only in rare cases should an amount beyond 24 pounds be given."

Stewart (*26*) in 1883 stated: "Twenty pounds of skim milk per day will be sufficient for the first 90 days, but no injury will occur from a larger ration as the calf grows older."

Milk fed at these maximum rates would amount to nearly 4,000 pounds for each calf if fed to 6 months of age, and nearly 2½ tons if fed to 8 months of age.

Several investigators long ago suggested that the period of whole-milk feeding might be shorter than 2 to 4 weeks. Pillsbury (*21*) in 1875 said "when calves are 5 days old they do well on milk that has been set 24 hours and skimmed. The best of the cream will raise by that time." Stewart (*26*) also stated that "the dairyman may feed whole milk for a single week, and then substitute skim-milk."

Other experiment station workers also showed long ago that the total milk-feeding period could be much shorter than 6 months. Fraser and Brand (*10*) in 1913 concluded that calves can be raised successfully if given a good start on whole milk for the first 3 weeks and then given about 12 pounds of skim milk daily until they are 8 weeks old. Swett (*27*) in 1919 and Fohrman[3] in 1923 reported weaning calves from all milk at 60 days of age, and Gullickson (*11*) in 1924 reported weaning calves from all milk at 60 to 70 days of age.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 30.

A number of experiment stations have also tried various substitutes, such as gruels and calf starters, in attempts to shorten the period of whole-milk feeding and to reduce the amount of liquid milk fed to dairy calves. Various grain feeds mixed with dry skim milk or some form of dried blood are commonly fed as dry "calf starters" or mixed with milk or water and fed as gruels. The results of this type of experimental feeding, which have been well summarized by Savage and McCay (*23*), indicate that the recommended amounts of whole milk fed with gruels or starters vary considerably at different experiment stations, that is, from 200 to 500 pounds for 30 to 60 days.

In discussing the limited-whole-milk and dry-calf-starter method in 1946, Norton and Eaton (*20*) said the two most important problems associated with this method are how much milk to feed and when to wean the calves. Stating that adherents of this method of rearing calves can be divided into two groups, they said:

> One group is represented by followers of the New Jersey system, wherein whole milk is limited to about 200 pounds and is fed only the first 30 days. Calves fed by this system usually receive a serious set-back at weaning and fail to grow at normal rates until 6 months to a year of age. This seems to be the greatest criticism of this method of feeding. It is doubtful indeed if it is wise to limit the use of whole milk to the extent that the growth of the calves is retarded unduly.
>
> A second group, which represents a greater number of investigators, has been inclined to be more liberal in the initial feeding of whole milk. Better results have been obtained where whole milk is fed in total amounts of 350 to 500 pounds until the calves are 50 days or more of age. Generally, it has been the opinion of this group that a more generous amount of whole milk fed over a longer period of time is an investment that pays good dividends.

In various discussions of such experiments, the advocates of liberal milk feeding seem to have based their decision on the temporary condition of the calf at 2 or 3 months of age rather than on its condition at later ages. For example, Norton and Eaton (*20*) said that when calves are limited to 200 pounds of whole milk for the first 30 days they "receive a serious set-back at weaning and fail to grow at normal rates until 6 months to a year of age." In discussing the same point, Savage et al. (*24*) cite the fact that Krauss and his coworkers (*14*) were able to raise Holstein calves on as little as 200 pounds of whole milk but complain that "for several months during the feeding period practically all the calves were rough and pot-bellied, a condition that seems to be characteristic of this system."

It is true that Krauss et al. (*14*) used the words "pot-bellied" and "shaggy" but what seems more important was the condition of these cheaply raised calves at older ages, which they describe as follows:

> Because during the second, third, and fourth months, dry-fed calves are apt to look rather pot-bellied and shaggy, a breeder anxious to have all his stock

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[3] Fohrman, M. H. MINIMUM MILK FOR CALF RAISING. Thesis for A. M. degree, University of Missouri. Columbia. 1919.

> looking at their best all the time may find this system undesirable. . . . By the time the calves are 6 months old, their physical appearance is good, although their finish is not quite equal to that of calves raised on liquid skim milk. At the end of the year, it is impossible to distinguish animals raised on a dry feed system from heifers of the same age raised on liquid skim milk.

The possibility that calves will have a scrubby appearance at early ages when they are reared on very small amounts of milk is the only criticism of this feeding method that has come to the author's attention. The appearance, of course, is not that of a calf raised on a nurse cow. The survival rates of calves reared on these small amounts of milk must have been satisfactory, or the investigators would have noted it in their reports.

The recuperative powers of the young bovine are remarkable. Both Waters (*28*) and Eckles and Swett (*9*) found compensation in the form of increased growth rate after a period of retardation. Eckles and Swett (*9*) did find, however, that animals whose diet was restricted over a sufficient period of time never became as large as those on normal diets. In the Bureau of Dairy Industry herds at Beltsville, Md., calves that were much undersized at 4 to 6 months have frequently made rapid rates of gain later and have completely recovered to expected weights.

CALF-FEEDING EXPERIMENTS AT BELTSVILLE

Rearing Calves Without Whole Milk

Prior to 1932, young calves in the Bureau's nutritional herd were generally reared according to the usual method, that is, they were fed whole milk for 30 days and then skim milk to 6 months of age. It was observed and reported in 1932 (*6*) that when the whole milk was obtained from cows that were being fed brown U. S. No. 3 timothy hay as the only roughage, the calves died before 90 days of age if they also had been fed this same quality of hay.

Later (*7*, *16*), experimental calves were reared according to the usual milk-feeding routine, but the whole milk was obtained from cows that were fed grain and a single roughage of either U. S. No. 3 alfalfa hay, U. S. No. 1 timothy hay, U. S. No. 1 clover hay, or U. S. No. 1 alfalfa hay, and also from cows that were on pasture. The hay fed to the calves was U. S. No. 3 timothy. The period of survival, freedom from blindness, and rate of gain by the calves seemed to be generally related to the amount of carotene (provitamin A) in the roughage that was fed to the cows and, consequently, to the amount of carotene and vitamin A in the whole milk fed to the calves.

From these early observations, it was thought that possibly the only reason calves might have to be fed whole milk in place of skim milk for the first few weeks after birth would be to provide them with a source of vitamin A. Therefore, to test this point, an experiment was planned in which calves were fed colostrum milk for about 3 days and then changed immediately to skim milk and a supplement of cod-liver oil or carotene as a source of vitamin A. The object of the experiment was to study the role of vitamin A in calf nutrition, rather than to develop changes in milk-feeding procedures.

The first calf placed on this rather radical experiment—a purebred Jersey male—was born July 1, 1933. After only 1 day on colostrum, the calf received skim milk supplemented with 20 cubic centimeters (4 teaspoonfuls) of cod-liver oil daily to 7 months of age. The total amount of skim milk was 2,063 pounds. In addition, the calf received a good grain mixture—up to a maximum of 5 pounds daily—but its only roughage feed was late-cut, very brown, U. S. No. 3 timothy hay.

The monthly gains in weight for the 7 months were as follows: 14, 29, 40, 50, 50, 51, and 23—a total gain of 257 pounds. According to Ragsdale (*22*), the expected gains for similar animals are: 18, 26, 37, 43, 49, 49, and 44—a total gain of 266 pounds. Figure 1 shows this calf at 3 and 6 months of age. Other male calves were reared in the same way during 1933 and 1934.

The results with these first calves proved so successful that the procedure became the basis for further experiments with vitamin A supplements. In these experiments, the basal ration was colostrum for 3 days (fed for its protective antibodies), followed by skim milk to at least 6 months of age. The skim milk was run through the separator several times to remove as completely as possible the milk fat, which carries the carotene and vitamin A of milk. Cod-liver oil, carotene in oil, or grated garden carrots were used as sources of vitamin A. The rest of the basal ration was late-cut, very brown timothy hay and a low-carotene grain mixture, which usually was made up as follows: White corn meal, 3 parts; wheat bran, 2 parts; soybean meal, 2½ parts; and linseed meal, 2½ parts.

During the period from July 1, 1933, to July 1, 1943, a total of 102 castrated male calves (69 Holsteins, 23 Jerseys, and 10 crossbreds) were reared on this experimental ration. The favorable results early in the experiment indicated that the procedure might well be used in farm practice, at least where skim milk is available, and trials were begun with Holstein female calves in 1934.

Results with two male calves that were fed reconstituted skim milk (1 pound of dry skim milk in 9 pounds of water) to 7 months of age after 3 days on colostrum indicated that this procedure might well be used in areas where whole milk is high in price and fluid skim milk is not available. Figure 2 shows one of these calves at 3 and at 6 months of age. Other investigators (*1*, *18*) have more recently confirmed the practicability of feeding fluid skim milk, supplemented with vitamin A, immediately after the colostrum period. Still others (*2*, *19*), however, have reported that reconstituted skim milk is less satisfactory than fluid skim milk.

From 1934 until 1942, more than half the Holstein females born in the nutrition herd at Beltsville were reared by this new milk-feeding regime, that is, with no whole milk except colostrum and with skim milk to 6 months of age. Experiments with Jersey females were not begun until September 1937, but in the next 2½ years about half the Jersey females born in the nutrition herd were reared in this way.

Table 1 gives the weights of the 34 females (26 Holsteins and 8 Jerseys) that were reared without normal whole milk, as compared with the weights of similar females that were fed whole milk for about a month before being changed to skim milk.

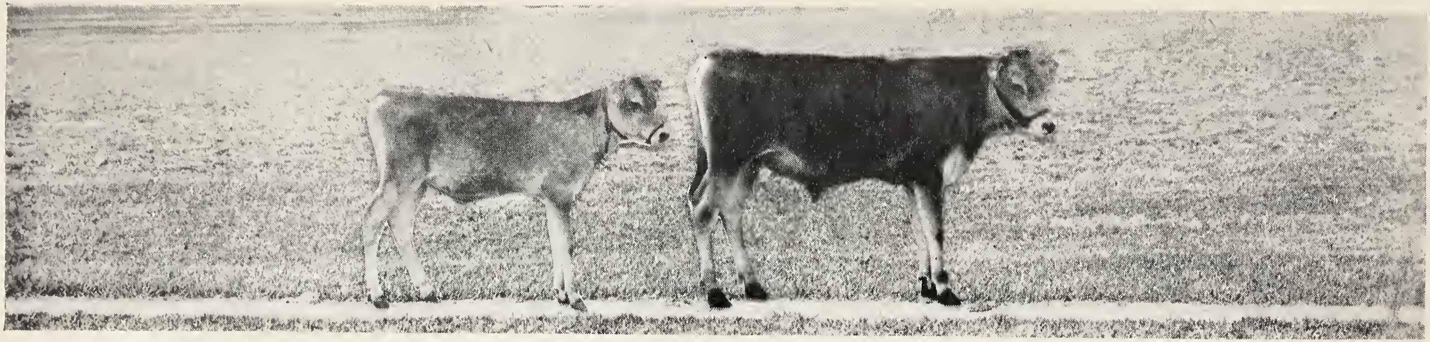

FIGURE 1.—Jersey steer, first calf reared without salable whole milk at Beltsville, shown at 3 and 6 months of age.

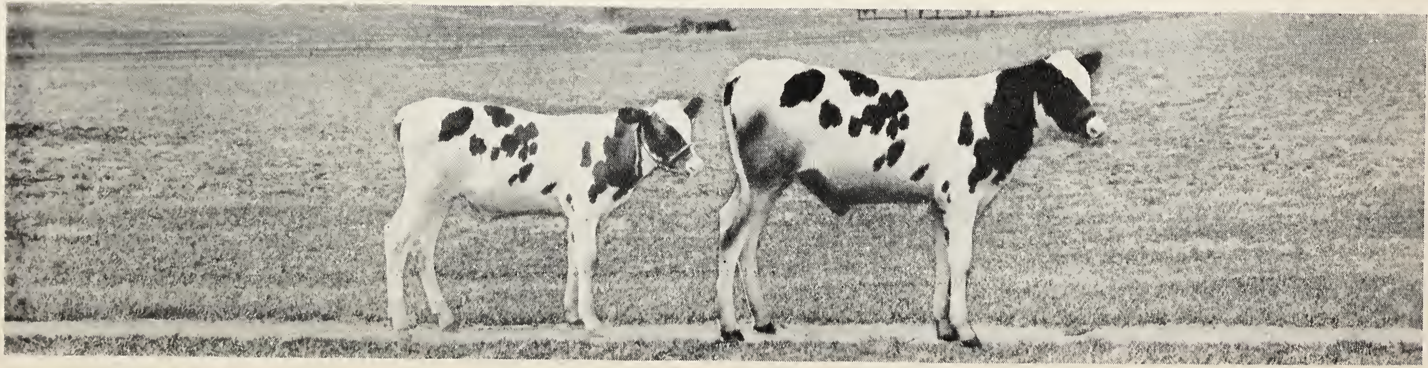

FIGURE 2.—Holstein steer at 3 months and at 6 months of age, raised on reconstituted skim milk to 6 months of age. It was fed a total of 233 pounds of dry skim milk, in water, supplemented with 4 teaspoons of cod-liver oil daily.

TABLE 1.—*Average monthly weight of female calves that were fed colostrum for 3 days followed by skim milk to 6 months of age, as compared with similar calves fed whole milk for 30 days followed by skim milk to 6 months of age*

Breed, and number of calves	Milk-feeding method	Weight at birth	Average weight at the age of (months)— 1	2	3	4	5
Holsteins:		*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
13	Whole milk for 30 days, then skim milk.	83	107	135	177	223	279
26	Colostrum 3 days, then skim milk.	84	101	135	181	233	288
Jerseys:							
6	Whole milk for 30 days, then skim milk.	48	65	87	116	151	191
8	Colostrum for 3 days, then skim milk.	48	57	78	108	145	186

Breed, and number of calves	Milk-feeding method	Weight at birth	Average weight at the age of (months)— 6	9	12	18	24
Holsteins:		*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
13	Whole milk for 30 days, then skim milk.	83	337	478	601	776	944
26	Colostrum 3 days, then skim milk.	84	346	483	607	821	986
Jerseys:							
6	Whole milk for 30 days, then skim milk.	48	238	347	448	628	764
8	Colostrum for 3 days, then skim milk.	48	230	341	454	613	787

In the Holstein groups, the calves that were fed whole milk for a month made an average gain of 7 pounds more during the first month than those that were fed no whole milk except colostrum. At the end of the second month, the average weight was the same for both groups. At all later ages indicated in the table, the group that got no whole milk averaged slightly heavier than the group that got whole milk for a month.

In the Jersey groups, the average gain for the first month was about 8 pounds in favor of the group that got whole milk for a month. This slight extra weight was maintained even after 6 months, but at 12 and 24 months of age the group that got no whole milk averaged slightly heavier than the group that got whole milk the first month.

WEANING CALVES FROM SKIM MILK BEFORE 6 MONTHS OF AGE

In 1942, when the war emergency made it desirable to conserve milk for human use, experiments were begun at Beltsville to find out how much earlier than 6 months of age calves could safely be weaned from skim milk. In general the experimental calves were reared without whole milk, except colostrum for about 3 days, after which they received skim milk and 2 to 4 teaspoons of cod-liver oil daily to 30, 45, 60, or 90 days of age.

They also received various roughages and the grain mixture described on page 21 as early as they would eat these feeds. As a rule the calves had access to the dry feeds only about 6 hours of the day, while they were in stanchions. Later in the experiment some of the calves were given access to the dry feeds for about 12 hours of the day. Also, some of the later calves were encouraged to eat grain at earlier ages by various methods. These differences in management are discussed in greater detail in the following pages.

Records are available for 28 Jersey steers, 23 Holstein steers, 13 Jersey females, and 8 Holstein females (72 calves in all) that were born and reared in the nutrition herd from 1942 to 1947.

RESULTS AS INDICATED BY MONTHLY WEIGHT GAINS

The average monthly weights of the different groups that were weaned from skim milk at various ages are given in table 2, as compared with the weights normally expected for similar calves at the same ages. (See Ragsdale, *22*.) Since no weights for castrated dairy males are available for comparison, the steers in these experiments are compared with the Ragsdale weights for dairy bulls of the same breed.

For the most part, the various groups lagged behind the normal monthly weight during the first few months of age and sometimes up to 6 months of age. Usually, too, the earlier the calves were weaned the greater was the lag in gain during the first and second month after they were weaned. But by the time the calves were 6 months of age, some of them had reached normal weight and even surpassed it. This tendency of young calves to recuperate after a period of retardation has been observed by others also (*9*, *28*).

For example, one Jersey steer that was weaned at 60 days was but 64 percent of normal weight at 3 months of age, but reached 88 percent of the normal weight at 6 months of age and 97 percent at 9 months. Another steer in the same group was 72, 80, and 94 percent of normal weight at 3, 6, and 9 months of age, respectively. These two steers gained 116 and 124 percent as much weight, respectively, as is normally gained between 6 and 9 months of age.

The nine Jersey steers that were weaned at 45 days of age were but 83 percent of the normal weight in the second and third months, but reached 96 percent of the normal weight by the time they were 7 months of age. The 11 Holstein steers that were weaned at 30 days of age were 80 percent of the normal weight at 2 months of age—1 month after weaning—but later they made rapid monthly gains and reached 95 percent and 103 percent of the normal weight at 6 and 9 months, respectively.

The males (castrates) in this experiment had greater difficulty than the females in reaching the Ragsdale normal weights. For years it has been observed at Beltsville that steers made poorer gains than females in the same experiment. In fact, a few steers that were fed the same (nonexperimental) rations as the females, in order to check on this point, did not make expected gains by the time they were 1 year of age.

TABLE 2.—*Average monthly weights of calves weaned from skim milk at various ages, as compared with Ragsdale standards (22) for similar calves fed normally*

Breed, sex, and number of calves	Age weaned	Weight at birth	Average weight at age of (months)—										
			1	2	3	4	5	6	9	12	18	21	24
	Days	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Jersey steers:													
7	90	58	65	87	122	160	210	266	[1] 378	-	-	-	-
12	60	57	66	88	118	159	209	276	[2] 390	-	-	-	-
9	45	59	71	86	117	160	210	265	398	-	-	-	-
Standard	-	60	78	104	141	184	233	282	410	-	-	-	-
Holstein steers:													
4	90	97	105	139	195	261	333	417	-	-	-	-	-
8	60	93	96	125	164	218	288	363	[2] 504	-	-	-	-
11	30	96	109	132	179	239	308	381	[3] 579	[3] 739	-	-	-
Standard	-	94	125	164	214	269	336	399	563	741	-	-	-
Jersey females:													
1 [4]	90	47	57	87	118	156	198	252	363	483	667	722	806
3 [5]	90	53	64	89	121	161	205	258	386	497	646	707	813
3 [6]	90	51	57	78	103	146	177	228	353	473	664	728	815
6 [6]	60	53	68	93	113	145	191	244	375	472	605	701	809
Standard	-	53	67	90	121	158	199	243	360	450	601	665	733
Holstein females:													
2	60	84	91	117	156	215	295	366	499	615	823	903	1,008
3	45	77	93	122	160	203	251	301	450	575	799	893	1,013
3	30	89	108	137	177	235	293	350	506	641	826	[2] 938	[2] 1,133
Standard	-	90	112	148	193	243	297	355	509	632	845	952	1,069

[1] 1 animal only.
[2] 2 animals only.
[3] 7 animals only.
[4] Received whole milk to 90 days of age.
[5] Received whole milk for 30 days, then skim milk.
[6] Received colostrum for 3 days, then skim milk.

So far as is known, no data are available for comparing monthly gains by dairy bulls and dairy steers. Black and Knapp (*4*) reported that, with animals of the beef and milking strains of Shorthorns, the steers were intermediate in weight between the heifers and bulls at all ages. At 140 days of age, the difference between the bulls and steers of the beef strain was 34 pounds more than the difference between the bulls and steers of the milking strain. Within the milking strain, the bulls were 33 pounds heavier than the steers at 8½ months of age and 189 pounds heavier at 1 year of age. Thus, at 8½ months of age, the steers were only about 94 percent as heavy as the bulls; so it is possible that 95 percent of the normal weight of dairy males may be normal for dairy steers.

Unfortunately, the number of calves (particularly females) in this skim-milk feeding experiment was too small to permit a clear differentiation between the effects of weaning at 30, 45, 60, or 90 days of age. Differences in management or in the amount of grain fed may have had as much effect on the gains in weight as the age of weaning. For example, the six Jersey females that were fed colostrum for 3 days and skim milk to 60 days of age averaged 191 pounds at 5 months of age, while the three Jersey females that were fed colostrum for 3 days and skim milk to 90 days of age averaged only 177 pounds at 5 months. Both groups weighed the same at 12 months of age, but at 18 months the calves that were weaned at 90 days averaged 59 pounds heavier. All six of the calves that were weaned at 60 days of age were fed energy supplements with the skim milk (see p. 17) and five of the six had access to dry feeds over a longer period of the day (see p. 23), whereas none of the three calves that were weaned at 90 days of age had these advantages. On the other hand, the three calves that were weaned at 90 days of age were also in another experiment, where the only roughage was timothy hay and each received 2,000 pounds or more grain between 12 and 24 months of age. In contrast to this, four of the six calves that were weaned at 60 days of age received no grain after 12 months of age but were fed a variety of roughages during the second year.

RESULTS AS INDICATED BY HEIGHT AT WITHERS

Investigators differ in their opinions concerning the value of height at withers as a measure of results in calf-feeding experiments. Some investigators never use this measurement but report only the gains in weight, whereas other investigators report both the gain in weight and the height at withers. Still other investigators, notably at the Nebraska Experiment Station, report the heart-girth measurement and diagonal length as well as the height at withers and the gains in weight.

Considerable care is required in measuring the height at withers since the tension of the muscles and different positions of the head and feet may affect the height. Measurements of the 72 calves in the Beltsville experiments were made at monthly intervals. Four measurements were made each time—one on each side of the animal while it was in the same pose, and again after it had been moved to a different pose. The average of the four measurements is used to indicate the height at withers, as reported in table 3. The Ragsdale (*22*) measurements are included for comparison.

TABLE 3.—*Average height at the withers of calves weaned from skim milk at various ages, as compared with the Ragsdale standards (22) for similar calves fed normally*

Breed, sex, and number of calves	Age weaned	Average height at withers at the age of (months)—										
		1	2	3	4	5	6	9	12	18	21	24
	Days	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Jersey steers:												
7	90	27. 9	29. 3	30. 9	33. 1	35. 1	36. 4	[1] 41. 1	------	------	------	------
12	60	28. 0	29. 4	30. 9	32. 8	35. 1	37. 0	[2] 40. 3	------	------	------	------
9	45	28. 2	29. 0	30. 3	32. 5	34. 4	36. 5	[3] 40. 5	------	------	------	------
Standard	------	27. 9	29. 7	31. 5	33. 6	35. 5	37. 2	40. 4	------	------	------	------
Holstein steers:												
4	90	30. 4	31. 9	33. 8	35. 7	38. 0	40. 1	------	------	------	------	------
8	60	29. 8	31. 1	32. 6	34. 7	36. 5	38. 7	43. 9	[1] 47. 6	------	------	------
11	30	30. 4	31. 3	33. 0	34. 8	37. 0	38. 8	[3] 44. 1	[3] 47. 6	------	------	------
Standard	------	31. 2	33. 2	34. 8	36. 4	38. 8	40. 5	44. 2	47. 5	------	------	------
Jersey females:												
1 [4]	90	26. 0	28. 5	30. 7	31. 7	33. 5	35. 4	39. 0	41. 3	44. 5	45. 8	46. 2
3 [5]	90	27. 3	29. 4	31. 5	33. 0	35. 3	36. 4	40. 0	43. 0	45. 8	46. 7	47. 6
3 [6]	90	27. 0	28. 7	30. 3	31. 9	33. 3	35. 2	38. 7	41. 3	45. 6	46. 7	47. 5
6 [6]	60	27. 6	29. 4	30. 6	32. 3	34. 4	36. 3	40. 2	42. 6	45. 6	46. 6	47. 1
Standard	------	27. 0	28. 9	30. 6	32. 6	34. 5	36. 2	40. 1	42. 2	45. 2	46. 2	46. 9
Holstein females:												
2	60	29. 8	31. 0	32. 3	34. 6	37. 0	40. 0	43. 0	45. 7	49. 8	51. 0	51. 9
3	45	29. 5	30. 9	32. 6	34. 1	35. 9	37. 2	41. 5	44. 5	48. 7	50. 0	50. 7
3	30	30. 2	31. 1	33. 1	35. 1	37. 1	38. 6	42. 9	45. 7	49. 8	[2] 50. 0	[2] 51. 0
Standard	------	30. 6	32. 3	34. 3	36. 2	37. 7	39. 7	43. 5	46. 0	49. 3	50. 6	51. 7

[1] 1 animal only.

[2] 2 animals only.

[3] 7 animals only.

[4] Received whole milk to 90 days of age.

[5] Received whole milk for 30 days, then skim milk.

[6] Received colostrum for 3 days, then skim milk.

A comparison of the data on height at withers (in table 3) with the data on weight (in table 2) shows that the various groups of calves were no farther behind in skeletal development (height at withers) than they were in weight, as compared with the Ragsdale normal in each case.

The results of such a comparison are more easily seen in table 4, where the data have been summarized by breed and sex to show the percentages of the normal height or weight reached by the various groups at 3, 6, 9, and 12 months of age.

Table 4.—*Percentage of normal weight and height at withers reached by early weaned calves at various ages*

Sex, number, and breed of calves	Age weaned	Age of comparison	Percentage of normal	
			Weight	Height at withers
	Days	*Months*	*Percent*	*Percent*
Steers:				
28 Jerseys	45 to 90	3	84	97
		6	95	98
23 Holsteins	30 to 90	3	84	95
		6	97	97
9 Holsteins	30 to 60	9	97	99
7 Holsteins	30	12	100	100
Females:				
9 Jerseys	60 to 90	3	89	100
		6	97	98
		9	101	97
8 Holsteins	30 to 60	3	85	95
		6	95	98
		9	95	97

It will be noted in table 4 that, at 3 months of age, the various groups were from 84 to 89 percent of the normal weight and from 95 to 100 percent of the normal height. At 6 months of age, the corresponding percentages for weight and height were 95 to 97 and 97 to 98, respectively. It will be observed also (in table 3) that even though the calves were somewhat below normal weight at early ages they were close to normal height at all ages. Eckles and Swett (*8*) also had observed that during periods of adverse treatment the rate of skeletal gain (height at withers) was more nearly normal than the gain in body weight.

CONDITION OF THE EARLY WEANED CALVES

The condition of the calves that were weaned from skim milk at 90 days of age and at earlier ages was observed throughout the experiment, and each calf was photographed at monthly intervals to preserve the record of its condition.

Figure 3 is a composite of the individual photographs of seven Holstein steers, that were weaned at 30 days of age, as they appeared at 6 months of age. Figure 4 is a composite picture of seven Jersey steers, that were weaned at 45 days of age, as they appeared at 9 months

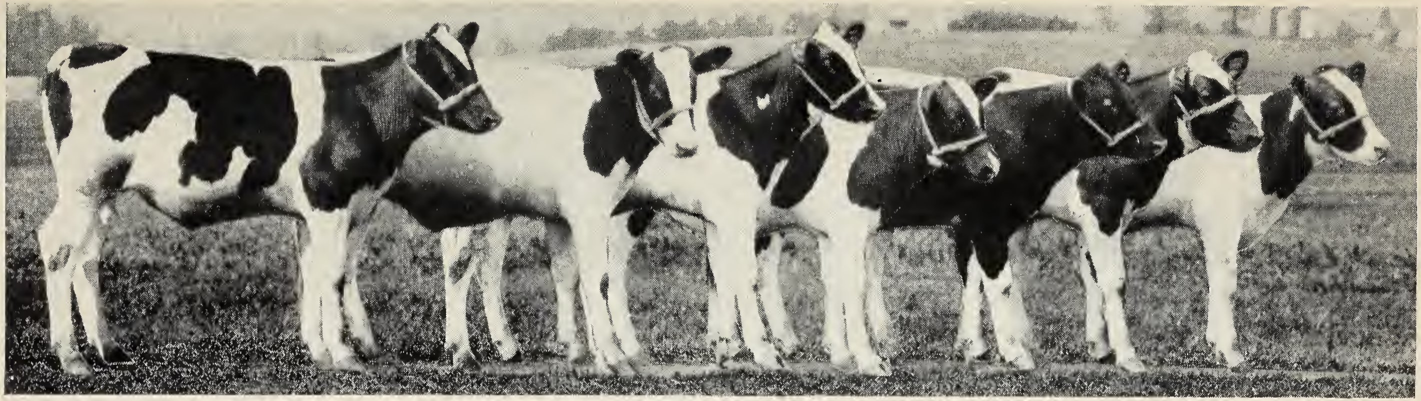

FIGURE 3.—These seven Holstein steers were fed on whole milk except colostrum and consumed on the average 234 pounds of skim milk to 30 days of age. They received no skim milk or other animal protein after 1 month of age, and the average weight at 6 months of age was 381 pounds.

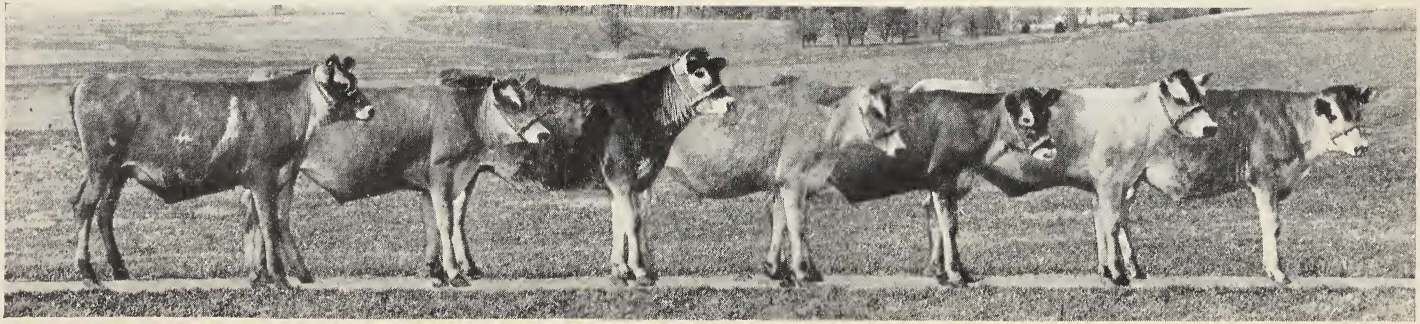

FIGURE 4.—These seven Jersey steers, which were weaned at 45 days of age and had consumed on the average 404 pounds of skim milk, had an average weight of 398 pounds at 9 months of age, or 98.5 percent of the expected weight.

of age. None of the calves in this experiment showed any evidence of any serious temporary disadvantage from weaning at early ages, and certainly no evidence of permanent disadvantage. They were all very acceptable animals.

Figure 5 shows the condition of four Holstein heifers at 6 months of age that were fed various amounts of whole milk and skim milk and weaned at various ages. The heifer at the extreme right had whole milk to 180 days of age; the other three (from left to right) had no whole milk but colostrum for several days and were weaned from skim milk at 30, 60, and 180 days, respectively. At 6 months of age, the heifer (extreme left) that was fed skim milk to 30 days of age was smaller than either the heifer that was fed skim milk to 180 days of age or the heifer that was fed entirely on whole milk, but at 1 year of age the early weaned heifer was larger than any other animal in the group. The condition of these calves indicates that large quantities of milk are not necessary in rearing acceptable herd replacements.

The rough and pot-bellied condition which other investigators (*14*) have cited as characteristic of calves that are fed as little as 200 pounds of whole milk was not observed among the animals in this experiment, although some of the calves had no whole milk whatever (except colostrum) and had less than 300 pounds of skim milk. Figure 6 shows the condition of a Holstein male calf, at monthly intervals from 2 to 6 months of age, which was weaned from skim milk at 30 days of age.

Figure 7 is a composite picture of 10 Holstein steers, each photographed at 3 months of age. They were weaned at 30 days of age and had consumed on the average only 229 pounds of skim milk, but no whole milk except colostrum. One of the calves (third from the right) shows a downswung belly but also a sway back—both the result of improper posing. The three calves at the right of the picture were photographed in December and January, when they had winter coats of long hair and also bare spots on the top of their necks that were caused by lice. Two of the three also were developing pneumonia on the day the photographs were taken. The calf on the extreme left of the picture was probably as badly out of condition as any of the early weaned calves. It had been weaned at 30 days of age and had also been fed an energy supplement (a commercial product consisting of dextrinized starch) that turned out to be very unsatisfactory for this purpose.

INFLUENCE OF MANAGEMENT PRACTICES AND SUPPLEMENTAL FEEDS ON EARLY WEANED CALVES

Does Milk Have Any Special Value as a Feed for Calves Over 30 Days of Age?

When the first Beltsville calves were to be weaned from skim milk at 90 or 60 days of age, it was thought necessary to feed large amounts of grain in order to replace the energy value of the milk that was withheld. In experiments with limited milk and dry calf-starters at other stations, calves were given maximum daily allowances of 5 or 6 pounds of grain—even with starters containing dry skim milk or dried

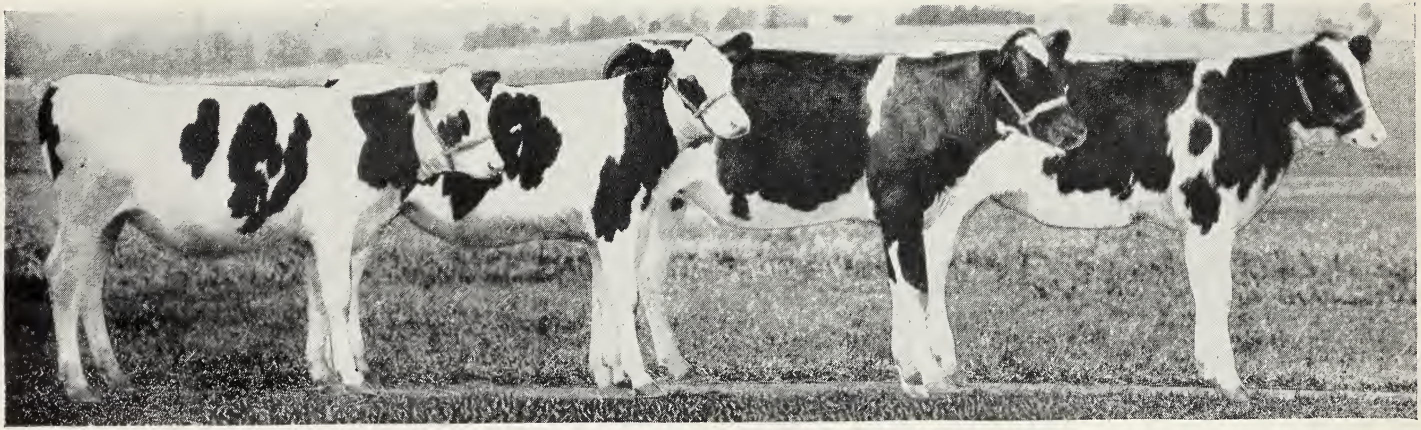

FIGURE 5.—Four Holstein heifers at 6 months of age that were weaned (left to right) at 30, 60, 180, and 180 days of age, respectively. The heifer at the right received no skim milk, but consumed 2,377 pounds of whole milk. The other three received no whole milk except colostrum, but consumed 278, 427, and 2,590 pounds of skim milk, respectively.

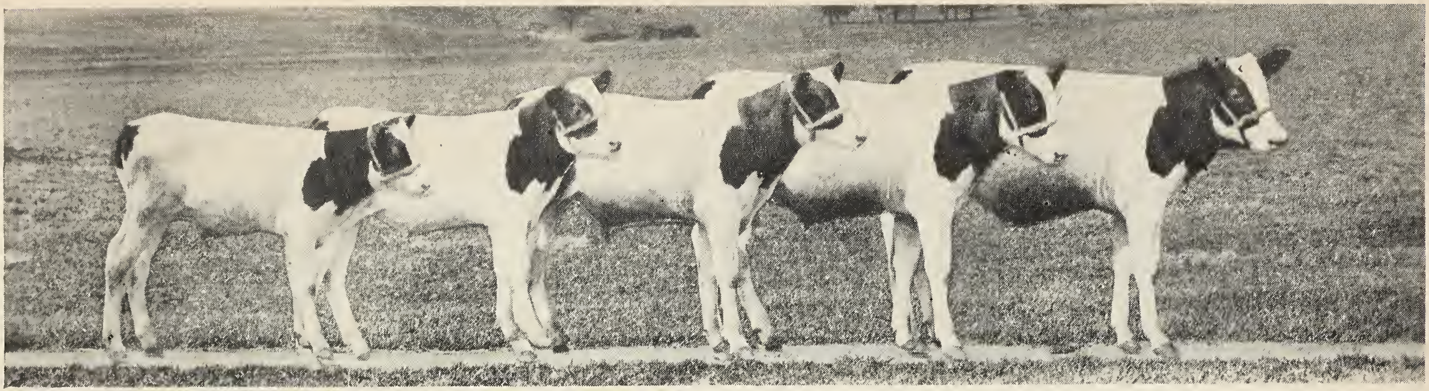

FIGURE 6.—A Holstein male calf as photographed at 2, 3, 4, 5, and 6 months of age. This calf was fed colostrum 3 days, then skim milk to 30 days of age.

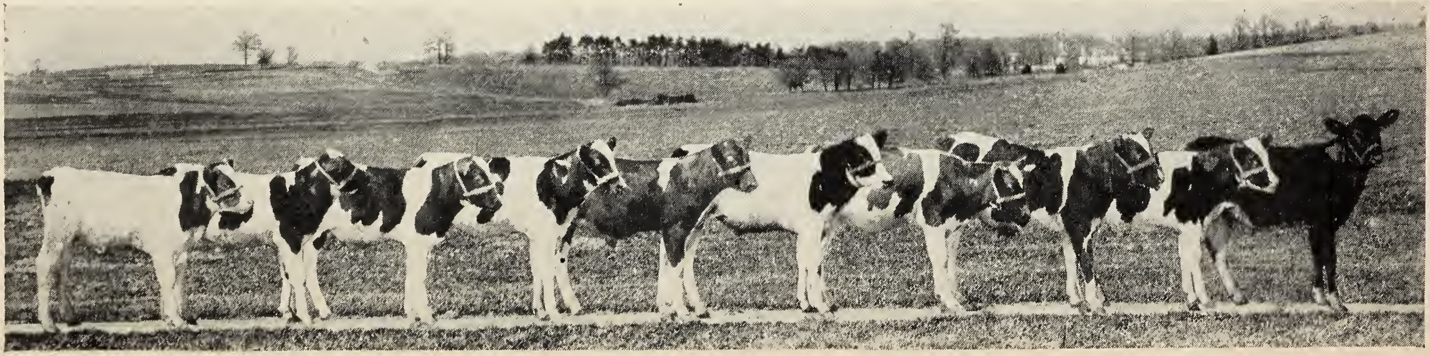

FIGURE 7.—A composite picture of 10 Holstein steers, each photographed at 3 months of age. These calves received no whole milk except colostrum, and consumed on the average only 229 pounds of skim milk to 30 days of age, after which they received no skim milk or other animal protein feed.

blood. Consequently, some of the first calves in the experiments discussed in this publication were allowed grain practically at will, and some of them ate as much as 7 pounds daily over considerable periods of time. Later, the maximum allowance of grain was reduced to 5 pounds daily or even less, apparently without any disadvantage, and the calves ate more hay.

When the feed consumed by the various groups of early weaned calves was converted into total digestible nutrients, by using average figures for feed composition, a rather startling discovery was made. The amount of total digestible nutrients consumed per pound of gain in body weight was not appreciably greater for the calves that received a small quantity of milk than for those that received a large quantity. Table 5 shows the comparative feed and energy consumption of the groups of calves weaned at different ages, and the amount of total digestible nutrients they consumed per pound of body gain.

Table 5 also affords a further comparison with calves in the female groups that were fed in a previous experiment [4] to determine their feed requirements for rapid growth but without undue fattening. The experiment included five Jersey females and five Holstein females that were fed whole milk to about 1 month of age, followed by skim milk to 6 months of age.

Based on the "required" amounts of feed nutrients for these groups, as listed in table 5, the five Jersey females got 34 percent of their total digestible nutrients from milk during the first 6 months, and the five Holstein females got 31 percent from milk. It is interesting to note that the female groups in the early weaning experiment, which got from 3 to 10 percent of their total digestible nutrients from milk, apparently used their intake of energy or nutrients just as economically as the animals that obtained from 31 to 34 percent of their nutrients from milk. Of course, the great handicap in all feeding experiments in which weight gains are used as the criterion for measuring results is the impossibility of determining the proportion of fat and lean in the gains.

Supplementing Skim Milk With Energy-Producing Feeds

Skim milk has only about half as much energy-producing value as whole milk for feeding calves. Therefore, when the colostrum feeding period is followed immediately by skim milk in about the same amounts as whole milk is usually fed, the energy intake is apt to be somewhat low and the gains in weight are apt to be less than when whole milk is fed—at least during the first month.

In an attempt to provide as much energy with skim milk as is possible with whole milk, the first thought might be to double the daily amount of skim milk. Even with an abundance of skim milk available, however, it would not be desirable to feed such large quantities of skim milk because the high lactose intake causes scours. Some years ago at Beltsville the author fed calves 18 to 25 pounds of skim milk daily during the first and second months, or from 50 to 100 percent more than the usual quantity for this period. Scours resulted, apparently caused by the large amount of lactose (milk sugar) in the

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[4] Unpublished data, from an experiment conducted in 1921–24 by the author for a thesis at the American University, Washington, D. C.

TABLE 5.—*Amount of total digestible nutrients consumed per pound of gain by the experimental calves from birth to 6 months of age*

Breed, sex, and number of calves	Age weaned	Feed consumed				
		Whole milk	Skim milk	Grain	Hay	Corn silage
	Days	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Jersey steers:						
7	90	[1] 21	715	506	219	------
12	60	[1] 19	419	539	239	------
9	45	[1] 20	397	441	350	------
Holstein steers:						
4	90	[1] 33	760	666	316	------
8	60	[1] 20	417	650	316	------
11	30	[1] 23	229	662	405	------
Jersey females:						
1 [2]	90	759	------	539	102	------
3 [3]	90	187	686	499	178	------
3 [4]	90	[1] 16	668	537	80	------
6 [4]	60	[1] 20	512	444	257	[5] 27
Required [6]	-------	199	1, 709	256	211	403
Holstein females:						
2	60	[1] 19	417	768	190	------
3	45	[1] 30	378	516	358	[5] 87
3	30	[1] 28	282	515	509	[5] 101
Required [6]	-------	240	1, 951	328	630	254

Breed, sex, and number of calves	Age weaned	Total digestible nutrients from—			Weight			Total digestible nutrients consumed per pound of gain
		Milk		All feeds	At birth	At 6 months	Gain	
	Days	*Lb.*	*Per cent*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Jersey steers:								
7	90	68	12	550	58	266	208	2. 64
12	60	41	7	560	57	268	211	2. 65
9	45	40	7	568	59	265	206	2. 76
Holstein steers:								
4	90	74	10	721	98	378	280	2. 58
8	60	41	6	677	93	363	270	2. 51
11	30	25	3	732	96	381	285	2. 57
Jersey females:								
1 [2]	90	136	23	588	47	252	205	2. 87
3 [3]	90	96	17	563	53	258	205	2. 75
3 [4]	90	63	13	502	51	228	177	2. 83
6 [4]	60	50	9	534	53	244	191	2. 80
Required [6]	-------	191	34	565	54	256	202	2. 80
Holstein females:								
2	60	42	6	697	84	366	282	2. 47
3	45	40	6	641	77	301	224	2. 86
3	30	31	4	716	89	350	260	2. 75
Required [6]	-------	221	31	711	103	363	260	2. 73

[1] Colostrum; no salable whole milk.

[2] Fed whole milk to 90 days of age.

[3] Received whole milk for 30 days, then skim milk.

[4] Received colostrum for 3 days, then skim milk.

[5] 1 animal only.

[6] See discussion, p. 17.

ration. Scours also resulted when dried whey was fed in addition to a normal amount of milk.

However, Woodward (*29*) in 1923 fed some Beltsville calves varying amounts of skim milk daily, starting after 15 days of age. Calves that were fed all they would consume (average of 24 pounds daily) gained 1.48 pounds daily over the 70-day experimental period, and calves that were fed at the rate of one-seventh of the body weight (average of 13.5 pounds daily) gained but 0.95 pound daily. Woodward said that no bad results from heavy feeding were noticed, although some of the calves that had all the skim milk they wanted drank more than 40 pounds a day at times. He concluded that overfeeding in itself is not a common cause of scours.

Experiments were also conducted at Beltsville, in which a commercial product consisting of dextrinized starch was fed in skim milk as an energy supplement. This product turned out to be very unsatisfactory for the purpose. Five of the 12 calves in the experiment died before they were 65 days of age, and the weight gains of those that survived indicated that the product, when fed in any of the amounts tried (420 to 100 grams daily), decreased the effectiveness of the ration of skim milk, grain, and hay.

Other investigators (*12*, *15*) have reported some success by emulsifying vegetable and animal fats into the skim milk. The only experiment at Beltsville with this method of increasing the energy intake was with skim milk into which cottonseed oil was emulsified. Only four calves were fed this "filled milk" and all died—at from 17 to 42 days of age. The amount of vitamin A fed with the filled milk was inadequate; but other calves that had the same amount of vitamin A, but no cottonseed oil in the skim milk, usually lived longer. Apparently cottonseed oil, like dextrinized starch, is not a suitable energy supplement for skim milk.

More recently, in the early weaning experiments at Beltsville, other energy supplements have been fed in skim milk until the calves were weaned, and then fed in warm water. Different groups of calves have been fed in this way on such supplements as corn meal, ground soybeans, oatmeal gruel, flaxseed jelly, and the same grain mixture that was subsequently fed dry. Starting usually with a quarter of a pound daily at 5 to 12 days of age, the amount of the supplement was usually increased to a half pound within a few days and then fed at that rate to 60 to 90 days of age.

The supplement of ground soybeans proved to be particularly unpalatable, and the oatmeal gruel was unsatisfactory because of its tendency to cause a pasty feces which stuck to the calf.

The calves did not clean up the corn meal very well, especially when it was fed in water, and seemed to show more of a tendency to scour on this supplement. Of five calves that were fed corn meal in skim milk to 45 days of age, three refused to drink a mixture of corn meal and water after they were weaned and it was necessary to add a pound of skim milk at each feeding for a number of days in order to get them to take the corn meal. All five calves survived, however.

Feeding a grain mixture in skim milk, and in warm water after the skim milk was discontinued, proved quite successful. Twenty-three calves have been fed this supplement. In a few cases, as much as a half pound of the grain mixture was added to the daily feed of skim milk before the calf was 10 days old, but usually this much was not added until the calf was 15 or 20 days old. Usually, too, no more than a half pound of grain was added to the skim milk or water at any time. However, the last three Holstein calves in this experiment were fed more than a half pound of grain daily in the skim milk to 15 days of age, and the amount was then increased to about a pound daily before they were 30 days of age. At 40 days of age—10 days after weaning—these three calves were eating a pound of grain daily mixed in warm water, and in addition 2, 2½, and 3 pounds of dry grain, respectively.

Dry flaxseed was cooked to a jelly in water and fed to 39 calves as an energy supplement, and appeared to be the best of the various supplements tried in this experiment. It was more expensive than some of the others, however. With the Holstein calves, the amount of flaxseed jelly fed in the skim milk was usually increased to a half pound (dry basis) daily before the calves were 10 days old. The smaller Jersey calves seemed to do better, however, when the increase to a half pound was delayed until the calves were 12 to 15 days old.

Table 6 shows the average gains in body weight during the first month by calves that were fed energy supplements of flaxseed jelly, grain-in-milk, or corn meal, as compared with gains by calves that were fed no energy supplement other than the grain and hay they would eat voluntarily from the manger.

Table 6.—*First month gains of calves fed different energy supplements*

Energy supplement	Holsteins		Jerseys	
	Animals	Gain first month	Animals	Gain first month
	Number	*Pounds*	*Number*	*Pounds*
No energy supplement	13	7.6	15	6.1
Corn meal	4	12.5	5	9.6
Grain in milk	15	12.8	8	10.9
Flaxseed jelly	22	15.6	17	11.6

The calves that were fed flaxseed jelly made better average gains the first month than those that were fed the grain mixture as an energy supplement. Both groups made better gains, however, than the groups that were fed no energy supplement. The group that was fed corn meal as an energy supplement made almost as large gains as the grain-fed group, but corn meal is considered less satisfactory for this purpose because calves do not eat it as well as they eat the grain-in-milk mixture.

Meeting the Protein Requirements of Early Weaned Calves

The protein requirements of growing dairy calves have never been determined with exactness. Morrison (*17*) says that a calf meal for use with fluid milk should contain 20 percent of protein, and thus must include a rather large proportion of protein-rich supplements. When calf meals or starters are substituted for whole milk, Morrison recommends feeding a high-quality protein up to 3 or 4 months of age, and states that "a considerable part of the protein in the concentrate mixture should come from an animal byproduct such as dried skim milk or buttermilk, dried blood or fish."

In a report on feed supplies during the recent war, Bethke (*3*) said "if the usual supply of milk fed to calves up to 6 months of age is decreased, certain critical materials (protein, vitamin, and mineral supplements) must be made available to take the place of milk."

These statements appear to indicate that the quantity and quality of protein to select for early weaned calves might be a problem.

In the Beltsville experiments, however, the growth and condition of the calves indicated that they got sufficient protein from a ration of skim milk, grain mixture, and high-quality alfalfa hay, without any high-protein supplement of animal origin.

Most of the early weaned calves were fed either grain mixture No. 75 (which consisted of 2 parts corn meal, 2 parts wheat bran, and 1 part linseed oil meal) or grain mixture No. 65 (which consisted of 3 parts corn meal, 2 parts wheat bran, 2½ parts linseed oil meal, and 2½ parts soybean oil meal). Grain mixture No. 75 contained about 17 percent crude protein and about 0.14 percent calcium; whereas grain mixture No. 65 contained about 25 percent crude protein and about 0.20 percent calcium. Unfortunately, the 17-percent protein mixture was not fed to calves that were weaned from skim milk before they were 60 days of age. However, the results with calves that were weaned at older ages indicate that this mixture together with alfalfa hay provided adequate amounts of protein.

Table 7 shows the average daily intake of digestible protein by four Holstein steers and seven Jersey steers in the Beltsville experiment that were fed grain mixture No. 75 and U. S. No. 1 alfalfa hay, and that were weaned from skim milk at 60 days of age. The digestible protein intake was calculated by using average figures for the composition of the feeds. The intake data are probably conservative, since the digestible protein content of the alfalfa hay was based on Morrison's average of 10.6 percent for "all analyses," whereas only U. S. No. 1 alfalfa hay with a higher percentage of leaf was fed. For comparative purposes, intake data are also included in the table for calves reared in the usual way on a ration of grain, alfalfa hay, and corn silage, with whole milk for about 1 month and skim milk to 6 months of age. The intake data for these groups are not to be considered as representing their requirements, however.

By the fourth month the early weaned calves had a digestible protein intake from grain and hay that was equal to that of the calves fed in the usual way with skim milk to 6 months of age. The early weaned calves, which were fed a grain mixture containing 17 percent crude protein, had a digestible protein intake at least as great as Morrison's maximum requirements, even during the first month after skim milk was removed from the ration. Further calculations indicate that if these calves had consumed the same amounts of a grain mixture composed of equal parts of corn and oats their digestible protein intake would have equaled Morrison's minimum requirement during the third month and the maximum requirement by the fourth month.

TABLE 7.—*Daily intake of digestible protein by calves weaned from skim milk at 60 days of age, as compared with the Morrison requirements and with the intake by calves fed in the usual way with skim milk to 6 months of age*

Group	Daily intake of digestible protein during the—			
	Third month	Fourth month	Fifth month	Sixth month
Holsteins:	*Pounds*	*Pounds*	*Pounds*	*Pounds*
4 steers weaned at 60 days of age	0. 52	0. 84	1. 08	1. 28
Morrison requirements:				
Minimum	. 35	. 48	. 60	. 68
Maximum	. 48	. 59	. 70	. 79
Calves fed in usual way [1]	. 75	. 85	. 90	. 95
Jerseys:				
7 steers weaned at 60 days of age	. 44	. 70	. 90	1. 13
Morrison requirements:				
Minimum	. 24	. 35	. 47	. 58
Maximum	. 40	. 48	. 58	. 68
Calves fed in usual way [1]	. 57	. 69	. 83	. 92

[1] From unpublished reports of experiments by H. T. Converse. These calves had grain, alfalfa hay, and corn silage, with whole milk for 1 month and skim milk to 6 months of age.

Two Holstein heifers that were weaned from skim milk at 60 days of age and three Jersey heifers that were weaned at 90 days of age were fed timothy hay and grain mixture No. 65, which contained about 25 percent crude protein. The two Holsteins and one of the Jerseys were normal in weight at 6 months of age and almost normal at 5 months. The other two Jerseys were about normal in weight by the time they were 10 or 12 months of age. Thus, it would appear that a ration of timothy hay and a grain mixture containing 25 percent of crude protein is adequate for calves weaned from milk as early as 60 days of age, provided the grain mixture contains some plant byproduct constituents such as linseed oil meal or soybean oil meal.

ENCOURAGING THE CALVES TO EAT DRY FEEDS EARLY

Mention has been made in the preceding pages about the desirability of getting the new-born calves to eat dry feeds as soon as possible and in generous amounts, as a prelude to early weaning from skim milk. Several methods were used in these experiments, which may be of interest.

Grain and hay were usually placed before the calves by the time they were 10 days of age. Early in these experiments, however, it was observed that the calves that were weaned at 60 days of age made much less gain in weight than those that were weaned at 90 days of age, indicating that the energy intake of the earlier weaned calves was insufficient for rapid growth.

Therefore, in an effort to encourage the calves to eat dry feeds earlier, grain was frequently stuffed into the calf's mouth, rubbed on its wet muzzle, or dusted into the bucket just as it had finished drinking most of the milk. Another method, mentioned previously, was to mix the grain mixture with the skim milk or with warm water after the skim milk was discontinued. These methods seemed to induce earlier and larger consumption of dry grains.

Later on in these experiments, when calves were first being weaned from skim milk at 30 days of age, it was thought that a change in the system of pen management might be advantageous. Bohstedt (*5*) had reported that group-fed baby beeves ate more feed and consequently made more rapid gains than stanchion-fed comparable animals. He suggested that the greater consumption of feed by the group-fed calves was due to "competition" around a common feed trough. At least, the group-fed calves were able to eat, drink, and lie down frequently and at will.

Up to December 1943, the system of pen management for the early weaned calves at Beltsville was the same as had been used for years for all calves at this station. All calves, even those as young as 1 month of age, were put in stanchions to eat dry feeds for a 3-hour period from 5 to 8 o'clock each morning, and then turned loose in the pen until about 1 p. m., when they were again put in stanchions to eat for about 2½ hours. Thus under this system the calves had access to dry feeds for only about 5 hours of the day and were without an opportunity to eat feed for about 19 hours out of the 24-hour period.

Starting in December 1943, a few calves were managed differently as an experiment. From 5 a. m. until midnight, the calves were in stanchions for 3 hours, loose for 2 hours, stanchioned for 2½ hours, loose for 2 hours, stanchioned for 2 hours, loose for 4 hours, and stanchioned for 3½ hours or until midnight. Thus, the calves handled in this way had four periods totaling 11 hours in stanchions with an opportunity to eat dry feeds, and they were loose in the pen without access to feed for only 13 hours.

Six Holstein males and three Jersey males were reared to 6 months of age under this new "special" system of pen management, and comparable control animals were reared under the "regular" system. Table 8 shows the daily consumption of hay and grain by the calves reared under each system of pen management.

The calves usually were changed from individual pens to group pens at from 30 to 35 days of age. Even during the second month, both Jerseys and Holsteins in the "special" pen system ate less grain than the calves in the "regular" pen system, but the former ate about 65 percent more hay. During the third, fourth, fifth, and sixth months, both the Jerseys and the Holsteins in the "special" pen system ate considerably more hay than those handled in the regular way.

Table 9 shows the total amount of grain and hay consumed on the average by the calves under each system of management, from the third to the sixth month, inclusive.

From the third to the sixth month, inclusive, the Holsteins in the special pen ate 21 percent more grain and 25 percent more hay than those in the regular pen system. During the same period, the Jerseys in the special pen system ate 5 percent less grain but 39 percent more hay than those in the regular pen system.

TABLE 8.—*Grain and hay consumption by early weaned calves under different systems of pen management*

System of pen management	Calves	Average daily consumption per calf during—									
		Second month		Third month		Fourth month		Fifth month		Sixth month	
		Grain	Hay	Grain	Hay	Grain	Hay	Grain	Hay	Grain	Hay
Holsteins:	*No.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Regular pen	5	1. 69	0. 25	3. 04	0. 97	3. 83	2. 19	4. 99	3. 20	6. 16	4. 23
Special pen	6	1. 65	. 41	3. 63	1. 38	4. 95	2. 77	6. 22	4. 13	6. 93	4. 97
Relative consumption [1] percent		98	164	119	142	129	126	125	129	113	117
Jerseys:											
Regular pen	3	. 93	. 12	2. 58	. 87	4. 03	1. 43	4. 91	2. 30	6. 21	3. 22
Special pen	3	. 65	. 20	2. 54	. 92	4. 03	2. 36	4. 55	3. 17	5. 80	4. 39
Relative consumption [1] percent		70	167	98	106	100	165	93	138	93	136

[1] Feed consumption by special pen calves expressed as a percentage of the consumption by regular pen calves.

After February 1944, the special pen management system was adopted as a regular procedure for all calves in the early weaning experiment. Thus, the results with most of the calves that were weaned at 30 and at 45 days of age were favorably affected by the system of management.

There is considerable evidence that even this special pen system of management is not as satisfactory for maximum roughage consumption as one in which the calves are completely free to eat, drink, and rest at will. On one occasion the night watchman turned nine calves loose in two pens but failed to close the stanchions, which allowed the calves to have free access to feed from midnight until morning. By that time all the mangers had been licked clean. These nine calves, for 2 days before and 2 days after this occasion, had left a total of 3 to 4½ pounds of hay in their mangers each day. On various other occasions, a single stanchion was accidentally left open, permitting all calves in the pen to nibble all night at the feed in the manger. The manger was always empty the next morning.

After August 1946, when the services of the night watchman were discontinued, it was not possible to leave the calves in the stanchions after 9 p. m. This increased the time the calves were loose in the pens and without access to feed by several hours. This system of special pen management, however, was as near group feeding as could be attempted with the labor that was available, and at the same time keep a record of the feed consumed by individual calves.

Table 9.—*Total amount of grain and hay consumed from the third to the sixth month, inclusive, by early weaned calves under different systems of pen management*

System of pen management	Calves	Average consumption per calf			
		Total grain		Total hay	
	Number	*Pounds*	*Percent*	*Pounds*	*Percent*
Holsteins:					
Regular pen	5	540. 9	100	317. 7	100
Special pen	6	651. 9	121	397. 5	125
Jerseys:					
Regular pen	3	531. 9	100	234. 6	100
Special pen	3	507. 6	95	325. 2	139

Table 10 shows the effect of the progressive improvement in management conditions during the early weaning experiment, as indicated by monthly weight gains of Jersey male calves that were reared under different conditions.

Seven Jersey steer calves were weaned at 90 days of age and five at 60 days and reared under the regular system of pen management, that is, without any special effort to induce them to eat dry feed at an early age. At 6 months of age, these two groups of calves had made weight gains equivalent to 94 and 85 percent, respectively, of the Ragsdale standard (*22*).

The next three Jerseys in the experiment were weaned at 60 days of age, and they were encouraged to start eating dry feeds early but did not have the benefit of the special pen management treatment. The gain in weight was 93 percent of the Ragsdale standard, or about the same as the group that was weaned at 90 days of age and reared under the regular system.

The last four calves were weaned at 60 days of age. Three of them were reared under the special pen management system but received no

TABLE 10.—*Effect of pen management system on the monthly gains of Jersey steer calves*

System of pen management	Average gain during—						Total gain for 6 months compared with Ragsdale normal [1]	
	First month	Second month	Third month	Fourth month	Fifth month	Sixth month		
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Pct.*
Regular pen:								
7 calves weaned at 90 days	7	22	35	38	50	56	208	94
5 calves weaned at 60 days	9	17	23	39	45	55	188	85
Regular pen, plus:[2]								
3 calves weaned at 60 days	6	22	32	35	45	67	207	93
Special pen:								
4 calves weaned at 60 days	10	29	37	48	59	59	242	109

[1] See discussion, p. 8.

[2] Encouraged to eat dry feeds early.

energy supplement, while the fourth received an energy supplement in the form of grain mixed in the milk but had no special pen treatment. This group averaged 9 percent heavier at 6 months of age than the Ragsdale standard.

THE IMPORTANCE OF WATER

Throughout the early weaning experiment, attention was given to the watering of the calves. As the amount of skim milk was reduced, warm water was substituted. Warm water was given twice a day after the calves were weaned from milk, whether or not an energy supplement was being added. The bucket feeding of warm water was continued until the calves were at least 4 months of age and usually to 6 months of age.

An occasional calf declined the warm water before 6 months of age, being satisfied with the general supply from the drinking cups in the pen, but most calves looked forward to the warm water as eagerly as a young calf does for milk. It was not unusual to see a 6-month-old calf stand and bawl at feeding time for a day or two after it was dropped from the water list.

Not only was warm water fed at feeding time for a period after weaning, but care was taken to see that water was available at all times when the calves were loose in the pens. When there was any question whether the calves were getting their fill from the drinking cups, water was provided by keeping buckets or tubs well filled in the pens. Care was taken to keep the drinking cups and other containers clean, since calves will frequently go thirsty for hours rather than drink from containers fouled with manure.

Even 10 or 12 pounds of milk does not supply all the liquid needed by a 2- to 4-month-old calf that is eating moderate amounts of dry feed. In some contemporary experiments, calves kept in individual pens without a water supply were being fed 12 pounds of milk daily. The calves refused to eat more than a small fraction of the amount of hay they should have eaten. When buckets of water were kept in the pens, hay consumption increased at an almost unbelievable rate.

SUMMARY AND CONCLUSIONS

For many years the traditional and orthodox recommendations for feeding young calves have been to always feed whole milk for at least 2 weeks, but preferably for 4 to 6 weeks; then gradually substitute skim milk for the whole milk at a rate no faster than 1 pound a day; and continue feeding skim milk until the calf is 6 months old or older. When no skim milk is available, the usual recommended procedure has been to feed 350 to 500 pounds of whole milk during the first 2 months, supplementing it with either a calf gruel or a dry calf-starter containing high-protein products of animal origin. The gruel or starter is usually discontinued at 4 months of age.

However, experiments have been conducted at Beltsville which indicate that it is practical to rear calves without any salable whole milk and with limited amounts of skim milk.

From July 1, 1933, to July 1, 1943, a total of 102 male calves and 34 female calves were reared successfully with no whole milk whatever. They were given colostrum for 3 days, then changed immediately to skim milk, which was supplemented with vitamin A, and continued on skim milk to 6 months of age. The source of the vitamin A was sometimes carotene in oil or 7 ounces of grated garden carrots, but more often it was 2 to 4 teaspoons of cod-liver oil. Two of the males were reared with "skim milk" that was made by mixing 1 pound of dry skim milk with 9 pounds of water.

In 1942, experiments were begun to find out how much earlier than 6 months of age the calves could be safely weaned from skim milk. After weaning at 90 days of age proved satisfactory, weaning at 60, 45, and 30 days of age was tried. Monthly weights and wither heights for 72 calves that were weaned at various ages, from 30 to 90 days, indicate that body weight may be somewhat under normal prior to 6 months of age but the tendency to recover is strong and most early weaned calves reach normal weight before they are 12 months of age, and some before 6 months. Wither heights tend to be more nearly normal than body weights during the first 6 months.

The so-called pot-bellied condition frequently complained of by other investigators was not a usual occurrence with the Beltsville early weaned calves, even though some were weaned as early as 30 days of age and consumed less than 300 pounds of skim milk. The calves received colostrum for 3 days but no salable whole milk at any time, and no dried milk, dried blood, or other protein supplement of animal origin was fed.

Feed consumption records show that the early weaned calves did not use more total digestible nutrients per pound of gain in body weight than did calves that were fed skim milk to 6 months of age. Some of the earlier weaned calves obtained as little as 3 or 4 percent of their total digestible nutrients from milk during the first 6 months, whereas calves that were fed skim milk to 6 months of age usually obtained 30 percent of their total digestible nutrients from milk during the same period. This appears to indicate that nutrients from grain and hay are as satisfactory for calves during the second and third months, and also in later months, as the nutrients from milk. The calf getting milk, grain, and hay eats a little more nutrients than the early weaned calf eats immediately after weaning and therefore makes a little larger gain in body weight.

Some of the early weaned calves were fed energy feeds along with the skim milk to increase the nutrient intake, starting at 10 days of age or earlier. Flaxseed cooked to a jelly, or the same grain mixture fed dry at older ages, proved to be valuable energy supplements when mixed with the skim milk, or with warm water after the skim-milk feeding was discontinued. A half pound of the dry grain daily was the amount usually fed, although as much as a pound was fed in a few cases.

A ration composed of alfalfa hay and a grain mixture containing 17 percent crude protein provided enough protein for calves that were weaned as early as 60 days of age, without the addition of any protein supplement of animal origin.

Calves that were given access to hay or other roughage while stanchioned during three or four 2- or 3-hour periods of the 24-hour day, with intervening periods for rest, exercise, and water, ate more roughage and made better gains than calves that had access to roughage during two longer periods of the day.

From the results of these experiments at Beltsville, it is apparent that a careful feeder can raise dairy calves satisfactorily for herd-replacement purposes without any salable whole milk and with less than 300 pounds of skim milk. Calves may be weaned as early as 30 or 45 days of age if they are eating a pound of grain daily and at least nibbling at hay by that time. Otherwise, weaning should be delayed until the calves are at least 60 days of age. A palatable grain mixture and leafy fine stemmed hay should be selected, and offered to the calves at least by the time they are 10 or 12 days of age, and an abundant supply of clean water—warmed if necessary—should be kept before the calves at all times.

BRIEF FEEDING SUGGESTIONS

The important points to consider in rearing early weaned calves may be summarized as follows:

MILK.—The new-born calf should have colostrum for 1 to 3 days and skim milk until it is 30 to 60 days of age, depending on the breed and other factors. Holstein calves may be weaned from skim milk at 30 to 60 days of age, and Jerseys at 45 to 60 days of age.

Cod-liver oil should be fed daily (2 to 4 teaspoons daily) with the skim milk to supply vitamin A until the calf is eating about a pound of fairly green hay daily.

If skim milk is fed at the rate of 8 pounds a day to 10 days of age, 10 pounds to 20 days of age, and 12 pounds to 30 days of age, only about 280 pounds of skim milk will be used per calf. If skim milk is fed to 60 days of age, the daily feed might be 8 pounds to 10 days of age, 10 pounds to 40 days, 6 pounds to 50 days, and 4 pounds to 60 days, or a total of about 460 pounds.

WATER.—As the daily feed of skim milk is reduced, an equal amount of warm water should be substituted for the skim milk. Pail feeding of warm water should be continued for a time after the calf is weaned, and an abundant supply of clean water that is not too cold should be available to the calf at all times thereafter.

GRAIN.—The grain mixture should be palatable and, during the first few months at least, it should contain 20 percent of high-protein concentrates. Two mixtures are suggested as follows: (1) Corn meal, 2 parts; wheat bran, 2 parts; and linseed oil meal, 1 part. (2) Corn meal, 3 parts; wheat bran, 2 parts; linseed oil meal, 2½ parts; and soybean oil meal, 2½ parts. The latter mixture may be slightly more palatable than the first.

If palatable legume hay is fed, any mixture of farm-grown grains can be substituted for the above mixtures by the time the calves are 4 months old. If grass hay is fed as the sole roughage, a calcium supplement should be added to the grain mixture until the calves are 6 months old (1 or 2 percent of bonemeal or ground limestone will be adequate).

Grain, and also hay, should be offered to the calves at about 10 days of age. To start the calves eating dry feeds as early as possible and in generous amounts, mix a small handful (about 2 ounces) of the grain mixture with each feeding of skim milk, beginning at 10 days of age or earlier, and double the amount by 20 days of age. Grain feeding should be increased gradually thereafter to a maximum of 4 pounds daily for Holsteins and 3½ pounds for Jerseys, and gradually reduced after the calves are 6 months of age. (No grain need be fed after the calves are 9 or 10 months of age, provided they have had plenty of good quality hay or other roughage.)

HAY.—Fine stemmed, leafy hay that is highly palatable should be selected for the young calf that is to be weaned from skim milk at an early age. Second cutting alfalfa hay, or an early cutting of a Ladino clover and grass mixture, will usually be very satisfactory.

The total amount of feed needed to 1 year of age by calves that are weaned at 30 to 60 days of age will be about as follows: Holsteins will need 200 to 400 pounds of skim milk, 475 to 550 pounds of grain, and 2,800 to 3,500 pounds of hay. Jerseys will need 350 to 450 pounds of skim milk, 450 to 550 pounds of grain, and 2,000 to 2,500 pounds of hay.

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